REMARKS

Claims 1-18 are pending in the application. By this amendment, claims 3-8, 11, 13, 15 and 17 are being amended to improve their form; marked up versions of the amended claims are attached hereto pursuant to 37 C.F.R. § 1.121(c)(ii). No new matter is involved.

In paragraph 1 on page 2 of the Office Action, claims 3-8, 11, 13, 15 and 17 are objected to because of certain informalities therein; specifically use of the term "from" in expressions such as "within a range of from 0.183". In response, Applicants are amending claims 3-8 11, 13, 15 and 17 to delete the term "from" in such expressions. Consequently, such claims as amended should now be clear and definite.

In paragraphs 3-8 of the Office Action, all of the claims are rejected under 35 U.S.C. § 103(a) on combinations of two or more of the references. More specifically, claims 1 and 5 are rejected on the combination of Iida '264 and Fujikawa '501. Claims 2, 6 and 9-18 are rejected on Iida '264 in view of Fujikawa '501 and Tamatsuka '708. Claims 3 and 7 are rejected on Iida '264 in view of Fujikawa '501 and Hourai '873. Claims 4 and 8 are rejected on Iida '264 in view of Fujikawa '501 and Tamatsuka '708 and further in view of Hourai '873. Claims 1, 3, 5, 7 and 9 are rejected on Hourai '873 in view of Fujikawa '501. Claims 2, 4, 6, 8 and 10-18 are rejected on Hourai '873 in view of Fujikawa '501 and Tamatsuka '708. These rejections are respectfully traversed for the reasons set forth hereafter.

Addressing first the rejection of claims 1 and 5 as unpatentable over Iida '264 in view of Fujikawa '501, according to the Office Action Iida discloses a method of forming a silicon wafer with an N-region formed over the entire surface. Although Iida does not disclose that the silicon single crystal is pulled while doping with carbon, Fujikawa is said to teach growing a silicon single crystal while controlling the oxygen concentration and the carbon concentration. The Office Action therefore concludes that it would have been obvious to a person of ordinary skill in art at the

time of the invention to modify Iida with Fujikawa in order to promote precipitation of oxygen and thereby produce an epi-wafer without an expensive EG treatment.

Upon review of Iida, it is noted that the reference discloses a method of forming a silicon wafer with an N-region formed over the entire surface, and that Fujikawa teaches growing a silicon single crystal while controlling the oxygen concentration and the carbon concentration. However, the present invention cannot be derived from the attempted combination of such references. Iida does not describe or suggest doping with carbon or promoting precipitation of oxygen. On the other hand, Fujikawa does not describe or suggest growing a silicon single crystal with an N-region. Any attempt at arriving at the present invention based on the combination of such references could result only with the benefit of hindsight and the teaching of the present invention. Therefore, claims 1 and 5 are submitted to clearly distinguish patentably over the attempted combination of references.

The pulling of a silicon crystal with an N-region while doping with carbon, in the case of claim 1, is based on the discovery that by doping with carbon, the single crystal having the N-region can be pulled faster than a single crystal in the case of not doping with carbon, and that improvement of productivity of the silicon single crystal having no grow-in defect and decrease in cost can be achieved. This was discovered for the first time in accordance with the present invention, as described at lines 16-21 of page 8 and at lines 2-17 of page 15 of the specification. Without the knowledge that a pulling rate possible to obtain the N-region shifts faster with doping of carbon, doping of the N-region crystal with carbon in the manner of the present invention cannot be derived. The cited references do not described or even suggest this. Therefore, claim 1 is submitted to clearly distinguish patentably over the attempted combination of Iida and Fujikawa. Similar comments apply to claim 5 which depends from and contains all of the limitations of claim 1.

Regarding the rejection of claims 2, 6 and 9-18 on the combination of Iida, Fujikawa and Tamatsuka, the Office Action maintains that the combination of Iida and Fujikawa teaches all the limitations of claim 2 except for doping of the silicon

single crystal with nitrogen. For this, Tamatsuka is looked to. Tamatsuka is said to teach a silicon single crystal doped with nitrogen in a predetermined interstitial oxygen concentration. The Office Action therefore concludes that it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the combination of Iida and Fujikawa with the teaching of Tamatsuka. Because a silicon single crystal wafer produced by doping nitrogen during growth of the silicon crystal wafer has a high getting capacity, growth of grown-in defects incorporated can be suppressed and density of oxide precipitates can be increased.

However, as Applicants have previously pointed out, as long as it is unknown that the pulling rate possible to obtain the N-region shifts faster by doping with carbon, a person of ordinary skill in the art could not derive the present invention from either in combination with Fujikawa. Moreover, while Tamatsuka discloses a silicon wafer doping with nitrogen to improve a getting capacity, the present invention cannot be derived from the combination of Tamatsuka with Iida and Fujikawa. Iida does not describe or suggest doping with nitrogen and carbon or promoting precipitation of oxygen. Fujikawa, on the other hand, does not describe or suggest doping with nitrogen and growing a silicon single crystal with an N-region. Furthermore, Tamatsuka does not describe or suggest growing a silicon single crystal with an N-region and doping with carbon. Therefore, the present invention is not obvious in view of the attempted combination of Iida, Fujikawa and Tamatsuka.

In claims 2 and 11, pulling of the silicon single crystal with an N-region while doping with carbon and nitrogen is based on the discovery that by doping with carbon, the single crystal having the N-region can be pulled faster than a single crystal in the case of not doping with carbon, and improvement of productivity of the silicon single crystal having no grow-in defect and decrease in cost can be achieved. The discovery in accordance with the present invention is described at lines 16-21 of page 8 and at lines 2-17 of page 15, as previously noted.

Again, and in accordance with the invention, by doping with nitrogen, the range of the pulling rate possible to obtain an N-region is expanded. However, in order to produce the N-region wafer, the pulling rate is necessarily lowered about 0.5 mm/min., as described at lines 18-25 of page 6 of the specification.

Further in accordance with the present invention, and as described at line 26 of page 6 through line 22 of page 7 of the application, a silicon single crystal is doped with not only nitrogen but also carbon to solve the problem that if nitrogen concentration to be doped is increased, expansion of the OSF region or generation of secondary defects may occur, so that very high nitrogen concentration cannot be employed, and nitrogen can stabilize the oxygen precipitation nuclei at high temperatures. However, the formation of precipitation nuclei at low temperatures is not a concern.

In accordance with the present invention, and as described at line 15 of page 16 through line 11 of page 17, by doping with carbon and nitrogen, the pulling rate possible to obtain the N-region is increased and expanded. Accordingly, by doping with the two dopants, both productivity and yield of the entire N-region wafer are simultaneously improved. Additionally, stable oxygen precipitation nuclei in a high temperature can be increased under the effect of nitrogen and stable oxygen precipitation nuclei in a low temperature can be also increased under the effect of carbon. Thus, the acceleration effect of oxygen precipitation is very strong in various temperature ranges. Therefore, even if any heat treatment is performed in a device process, high IG ability can be shown.

None of the cited references show or describe compensation of the weak point of doping nitrogen by doping with carbon to obtain a synergetic effect. In Tamatsuka, for example, because the acceleration effect of oxygen precipitation is obtained by doping with nitrogen, it is not necessary for one of ordinary skill in the art to dope further with carbon, in view of the teaching in Tamatsuka. To dope with not only nitrogen but with carbon, in the manner of the present invention, it must be acknowledged that by doping with carbon, the single crystal having the N-region

can be pulled faster, and the acceleration effect of oxygen precipitation is obtained at a low temperature. To the contrary, by doping with nitrogen, the single crystal having the N-region cannot be pulled faster, very high nitrogen concentration cannot be employed because generation of a secondary defect may occur, and nitrogen is not concerned with the formation of precipitation nuclei at low temperatures. Because these considerations are not acknowledged in the cited art, even a person of ordinary skill in the art could not derive the present invention from a combination thereof.

Therefore, claims 2 and 11 are submitted to clearly distinguish patentably over the attempted combination of references. Claims 6, 9, 10 and 12-18 are submitted to clearly distinguish patentably over the attempted combination of references for similar reasons.

Addressing the rejection of claims 3 and 7 on the combination of Iida, Fujikawa and Hourai, such claims depend on claim 1. Claim 1 clearly distinguishes patentably over the art, as previously discussed, and therefore claims 3 and 7 are also submitted to clearly distinguish patentably over the art.

Similar comments also apply to the rejection of claims 4 and 8 on the combination of Iida, Fujikawa, Tamatsuka, and Hourai. Such claims depend from claim 2 which distinguishes over the art, as previously discussed.

Regarding the rejection of claims 1, 3, 5 7 and 9 on the combination of Hourai and Fujikawa, the Office Action states that Hourai discloses a method of forming a silicon wafer with an N-region, in the manner of the present invention, with careful control of the pulling rate and temperature gradient. However, Hourai does not disclose that the silicon single crystal is pulled while doping with carbon. However, Fujikawa is said to teach growing a silicon single crystal while controlling the oxygen concentration and the carbon concentration. Therefore, according to the Office Action, it would have been obvious to one of ordinary skill in the art at the

time of the invention to modify Hourai with Fujikawa to promote precipitation of oxygen, thereby producing an epi-wafer without an expensive EG treatment.

In this regard, Applicants previous comments with respect to the rejection of claims 1 and 5 apply here as well. Certainly, Hourai discloses a method of forming a silicon wafer with an N-region formed over the entire surface, and Fujikawa teaches growing a silicon single crystal while controlling the oxygen concentration and the carbon concentration. However, neither reference shows or suggests that by doping the N-region crystal with carbon, the pulling rate possible to obtain the N-region shifts faster. Therefore, a person of ordinary skill in the art would not be lead to the present invention from such combination of references. Claims 1 and 9 are submitted to clearly distinguish patentably over the attempted combination of such references.

Regarding the rejection of claims 2, 4, 6, 8 and 10-18 on the combination of Hourai, Fujikawa and Tamatsuka, the Office Action maintains that the combination of Hourai with Fujikawa teaches all of the limitations of claim 2, for example, except for doping with nitrogen. Tamatsuka, on the other hand, is said to teach a silicon single crystal doped with nitrogen in predetermined interstitial oxygen concentration, so that it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Hourai and Fujikawa with Tamatsuka. This is because a silicon single crystal wafer produced by doping nitrogen during growth of the silicon crystal ingot has a high getting capacity, growth of grown-in defects incorporated can be suppressed and density of oxide precipitates can be increased. In this regard, Applicants previous comments with respect to the rejection of claims 2, 6 and 9-18 on the combination of Iida, Fujikawa and Tamatsuka also apply, so that claims 2, 4, 6, 8 and 10-18 are submitted to clearly distinguish patentably over the attempted combination of references.

In conclusion, claims 1-18 are submitted to clearly distinguish patentably over the cited art for the reasons discussed above. Therefore, reconsideration and allowance are respectfully requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles telephone number (213) 337-6846 to discuss the steps necessary for placing the application in condition for allowance.

If there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-1314.

Respectfully submitted,

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Version with markings to show changes made:

Rewrite claim 3 as follows:

3. (Amended) The method for producing a silicon single crystal according to claim 1, wherein the silicon single crystal is pulled while doping with carbon having concentration of 0.1 ppma or more and controlling V/G within a range of [from] 0.183 to 0.177 $mm^2/K \cdot min$.

Rewrite claim 4 as follows:

4. (Amended) The method for producing a silicon single crystal according to claim 2, wherein a silicon single crystal is pulled while doping with carbon having concentration of 0.1 ppma or more and controlling V/G within a range of [from] 0.183 to 0.177 $mm^2/K \cdot min$.

Rewrite claim 5 as follows:

5. (Amended) A method for producing a silicon single crystal, wherein the silicon single crystal produced by the method according to claim 1 is processed into wafers, and the wafers are subjected to heat treatment at a temperature of [from] 600 to 1000°C.

Rewrite claim 6 as follows:

6. (Amended) A method for producing a silicon single crystal, wherein the silicon single crystal produced by the method according to claim 2 is processed into wafers, and the wafers are subjected to heat treatment at a temperature of [from] 600 to 1000°C.

Rewrite claim 7 as follows:

7. (Amended) A method for producing a silicon single crystal, wherein the silicon single crystal produced by the method according to claim 3 is processed into wafers, and the wafers are subjected to heat treatment at a temperature of [from] 600 to 1000°C.

Rewrite claim 8 as follows:

8. (Amended) A method for producing a silicon single crystal, wherein the silicon single crystal produced by the method according to claim 4 is processed into wafers, and the wafers are subjected to heat treatment at a temperature of [from] 600 to 1000°C.

Rewrite claim 11 as follows:

11. (Amended) A method for producing a silicon epitaxial wafer formed an epitaxial layer on a surface of a silicon wafer produced from a CZ silicon single crystal pulled with doping with carbon and nitrogen in which the CZ silicon single crystal is grown, wherein the CZ silicon single crystal is pulled to have carbon concentration, nitrogen concentration and oxygen concentration of [from] 0.1 to 1 ppma, [from] 1×10^{13} to 1×10^{14} number/cm^3 and [from] 15 to 25 ppma, respectively, or [from] 1 to 3 ppma, [from] 1×10^{14} to 5×10^{15} number/cm^3 and [from] 10 to 15 ppma, respectively.

Rewrite claim 13 as follows:

13. (Amended) A silicon epitaxial wafer formed an epitaxial layer on a surface of a silicon wafer produced from a CZ silicon single crystal pulled with doping with carbon and nitrogen in which the CZ silicon single crystal is grown, wherein the silicon wafer has carbon concentration, nitrogen concentration and oxygen concentration of [from] 0.1 to 1 ppma, [from] 1×10^{13} to 1×10^{14} atoms/cm^3

and [from] 15 to 25 ppma, respectively, or [from] 1 to 3 ppma, [from] 1 x 10^{14} to 5 x 10^{15} atoms/cm^3 and [from] 10 to 15 ppma, respectively.

Rewrite claim 15 as follows:

15. (Amended) A method for producing an annealed wafer formed a denuded zone in a surface layer of a CZ silicon wafer and having oxide precipitates of 1 x 10^9 atoms/cm^3 in a bulk portion by performing a heat treatment to the CZ silicon wafer produced from a CZ silicon single crystal pulled with doping with carbon and nitrogen in which the CZ silicon single crystal is grown, wherein the CZ silicon single crystal is pulled to have carbon concentration, nitrogen concentration and oxygen concentration of [from] 0.1 to 1 ppma, [from] 1 x 10^{13} to 1 x 10^{14} atoms/cm^3 and [from] 15 to 25 ppma, respectively, or [from] 1 to 3 ppma, [from] 1 x 10^{14} to 5 x 10^{15} atoms/cm^3 and [from] 10 to 15 ppma, respectively.

Rewrite claim 17 as follows:

17. (Amended) An annealed wafer produced by performing a heat treatment to a CZ silicon wafer having carbon concentration, nitrogen concentration and oxygen concentration of [from] 0.1 to 1 ppma, [from] 1 x 10^{13} to 1 x 10^{14} atoms/cm^3 and [from] 15 to 25 ppma, respectively, or [from] 1 to 3 ppma, [from] 1 x 10^{14} to 5 x 10^{15} atoms/cm^3 and [from] 10 to 15 ppma, respectively, wherein BMD density in a bulk portion is 1 x 10^9 atoms/cm^3 or more.